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An analysis of the variability of the surface solar irradiance (SSI) at different local time-scales is presented in this study. Since geophysical signals, such as long-term measurements of the SSI, are often produced by the non-linear interaction of deterministic physical processes that may also be under the influence of non-stationary external forcings, the Hilbert-Huang transform (HHT), an adaptive, noise-assisted, data-driven technique, is employed to extract locally – in time and in space – the embedded intrinsic scales at which a signal oscillates.

The transform consists of two distinct steps. First, by means of the Empirical Mode Decomposition (EMD), the time-series is “de-constructed” into a finite number – often small – of zero-mean components that have distinct temporal scales of variability, termed hereinafter the Intrinsic Mode Functions (IMFs). The signal model of the components is an amplitude modulation - frequency modulation (AM - FM) one, and can also be thought of as an extension of a Fourier series having both time varying amplitude and frequency. Following the decomposition, Hilbert spectral analysis is then employed on the IMFs, yielding a time-frequency-energy representation that portrays changes in the spectral contents of the original data, with respect to time.

As measurements of surface solar irradiance may possibly be contaminated by the manifestation of different type of stochastic processes (i.e. noise), the identification of real, physical processes from this background of random fluctuations is of interest. To this end, an adaptive background noise null hypothesis is assumed, based on the robust statistical properties of the EMD when applied to time-series of different classes of noise (e.g. white, red or fractional Gaussian). Since the algorithm acts as an efficient constant-Q dyadic, "wavelet-like", filter bank, the different noise inputs are decomposed into components having the same spectral shape, but that are translated to the next lower octave in the spectral domain. Thus, when the sampling step is increased, the spectral shape of IMFs cannot remain at its original position, due to the new lower Nyquist frequency, and is instead pushed toward the lower scaled frequency. Based on these features, the identification of potential signals within the data should become possible without any prior knowledge of the background noises.

When applying the above outlined procedure to decennial time-series of surface solar irradiance, only the component that has an annual time-scale of variability is shown to have statistical properties that diverge from those of noise. Nevertheless, the noise-like components are not completely devoid of information, as it is found that their AM components have a non-null rank correlation coefficient with the annual mode, i.e. the background noise intensity seems to be modulated by the seasonal cycle.

The findings have possible implications on the modelling and forecast of the surface solar irradiance, by discriminating its deterministic from its quasi-stochastic constituents, at distinct local time-scales.